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Subject Category: PHYSICS

UNITED STATES ATOMIC ENERGY COMMISSION

THE TRANSMISSION OF NEUTRONS AND GAMMA-RAYS THROUGH AIR SLOTS. PART IX. THERMAL AND EPITHERMAL NEUTRON DISTRIBUTIONS AROUND AN AIR SLOT IN WATER

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September 1, 1954

Brookhaven National Laboratory
Upton, New York

Technical Information Service, Oak Ridge, Tennessee

ATOMIC ENERGY COMMISSION
UNITED STATES OF AMERICA

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Date Declassified: November 21, 1955.

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Printed in USA, Price 15 cents. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

BNL-2027

THE TRANSMISSION OF NEUTRONS AND GAMMA-RAYS THROUGH AIR SLOTS

Part IX

Thermal and Epithermal Neutron Distributions around an Air Slot in Water

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1 September 1954

Work performed under Contract No. AT-30-2-Gen-16

REACTOR DEPARTMENT

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.

under contract with the
United States Atomic Energy Commission

Part IX

Thermal and Epithermal Neutron Distributions around an Air Slot in Water

INTRODUCTION

This particular experiment is one of a group designed to shed further light on the processes taking place in neutron transmission through air slots. The method was to study in detail the flux distributions in water around an air slot.

SECTION 1
Experimental Arrangement

For this experiment, a special air slot was fabricated of one inch thick lucite walls. The dimensions of the slot were 1 x 33 x 45 inches, with the forty-five inch dimension vertical. The bottom of the air slot was 4.5 inches from the bottom of the water-filled BNL shielding tank. The slot was constructed in this way so that there would be negligible boundary effects and the detector could be placed relatively close to the air slot boundaries. Measurements were made with a one-inch diameter, six inches long, BF_3 counter, with and without a cadmium cover. A few measurements in the region of high flux were made with a natural uranium fission chamber.

SECTION 2
Experimental Results

Figure 1 shows the results for typical vertical and horizontal thermal neutron traverses made above the forty-five inch air slot in water. The upper end of the air slot was at Z = 49.5 inches, and the horizontal traverse was made at Z = 54 inches. As determined from the Z traverse, the neutron relaxation length was: seven inches above the slot -- 5 cm; and, twenty-five inches above the slot -- 7.7 cm. This indicated a hardening of the transmitted spectrum.

Figure 2 shows a series of vertical traverses made parallel with the vertical axis of the air slot in water. The most striking feature of these curves was the peak in the thermal flux opposite the end of the air slot. This indicated the presence of a localized low energy source at the end of the air slot, which is significantly more intense than the radiation transmitted through the sides of the slot. Figure 3 shows the same information with the water background subtracted from the data[1], so that the effect due to the slot alone is determined. Figure 4 shows similar curves measured with a cadmium-covered BF_3 detector, showing the same general characteristics.

[1] Background data have not been subtracted in Figures 1, 2, and 4.

Figure 5 shows the general features of the attenuation of the transmitted radiation in water as a plot of thermal neutron isodoses around the end of the air slot. These isodoses were generated from data which had been corrected for the effect of the water background. In general, the neutron isodoses were roughly elliptical above the slot and roughly parallel with the slot along the upper end. They tended to branch out near the bottom of the slot. It was not possible to obtain reliable measurements over a larger area because of the high background from the normal water transmission. The "elliptical" isodoses constituted definite evidence of a strong forward or collimated high energy component. This is in contrast with the semicircular isodoses previously observed in measurements of the transmission of intermediate energy neutrons through iron slabs[2]. Also, close to the end of the slot, there was definite evidence of roughly circular isodoses, corresponding to a localized low energy source.

The evidence for the former remarks, concerning the collimated component, is shown more strikingly in Figure 6, comparing the attenuation of thermal neutrons vertically and horizontally opposite the end of the slot. It is evident that the vertical traverse has a considerably longer relaxation length than the horizontal traverse far out in the water.

In the past, suggestions have been made that one might study the transmission of neutrons through a duct by making measurements in water along the side of a duct, rather than behind the end of ducts of varying lengths. To study this and associated questions, a measurement was made in detail down the length of the special lucite-walled air slot in water, four inches from the centerline of the slot. This measurement is shown in Figure 7. The results indicated that the radiation could be divided into two components: that transmitted to the end of the duct; and, that transmitted through the sides of the duct.

As demonstrated in Part II of this series, the portion transmitted through the end of the slot varies with the inverse square of the slot length for this particular geometry. The data in Figure 7 indicate that the portion transmitted through the sides varies as the inverse fourth power of the slot length. While the contribution of the inverse fourth power component to the flux measured immediately above the forty-five inch long slot was quite small, it could become an important fraction for shorter ducts.

[2] BNL-265 - "The Streaming of Neutrons in Carbon Steel", Shore, Schamberger, and Sleeper, Jr. (1 Dec 53)

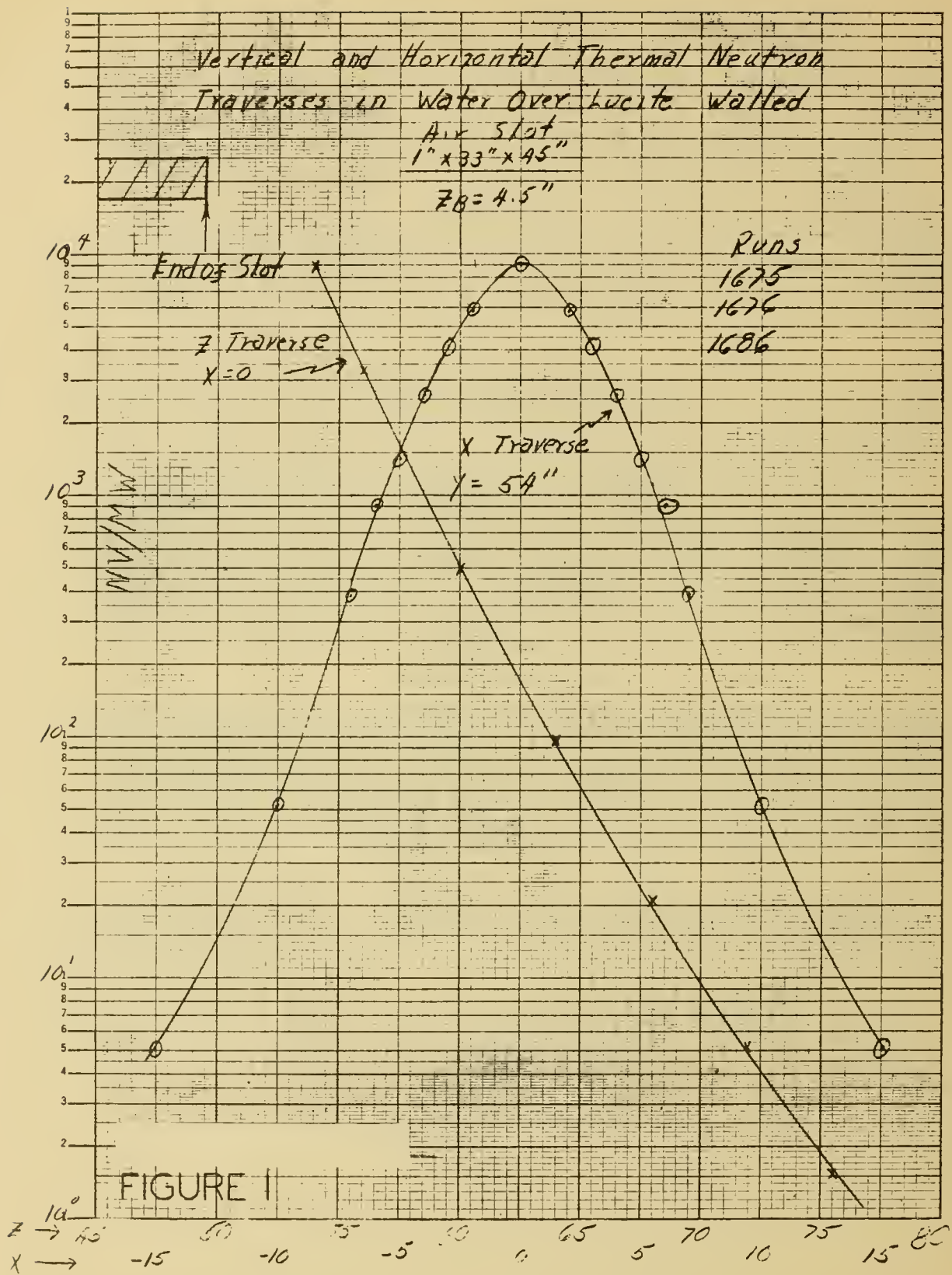
Vertical and Horizontal Thermal Neutron Traverses in Water Over Lucite walled Air Slot
1" x 33" x 45"
Z_B = 4.5"
End of Slot
Z Traverse
X = 0
X Traverse
Y = 54"
Runs
1675
1676
1686
MW/MW
10^4
10^3
10^2
10^1
10^0
Z →
X →
-15
-10
-5
0
5
10
15

FIGURE 1

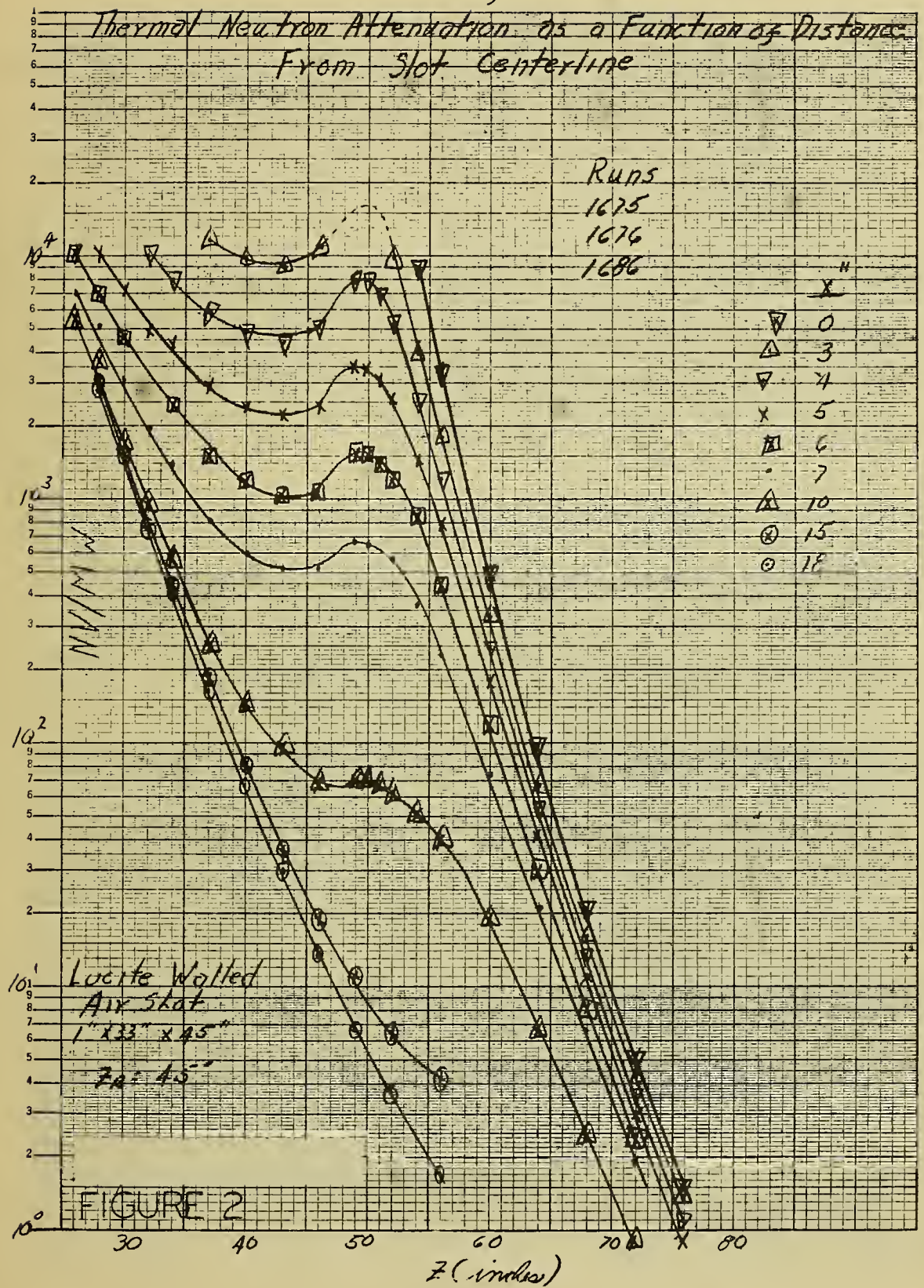
Thermal Neutron Attenuation as a Function of Distance From Slot Centerline
Runs
1675
1676
1686
X (inches)
0
3
4
5
6
7
10
15
18
Locite Walled
Air Slot
1" X 33" X 45"
Z_A = 45"
10^4
10^3
10^2
10^1
10^0
30
40
50
60
70
80
Z (inches)

FIGURE 2

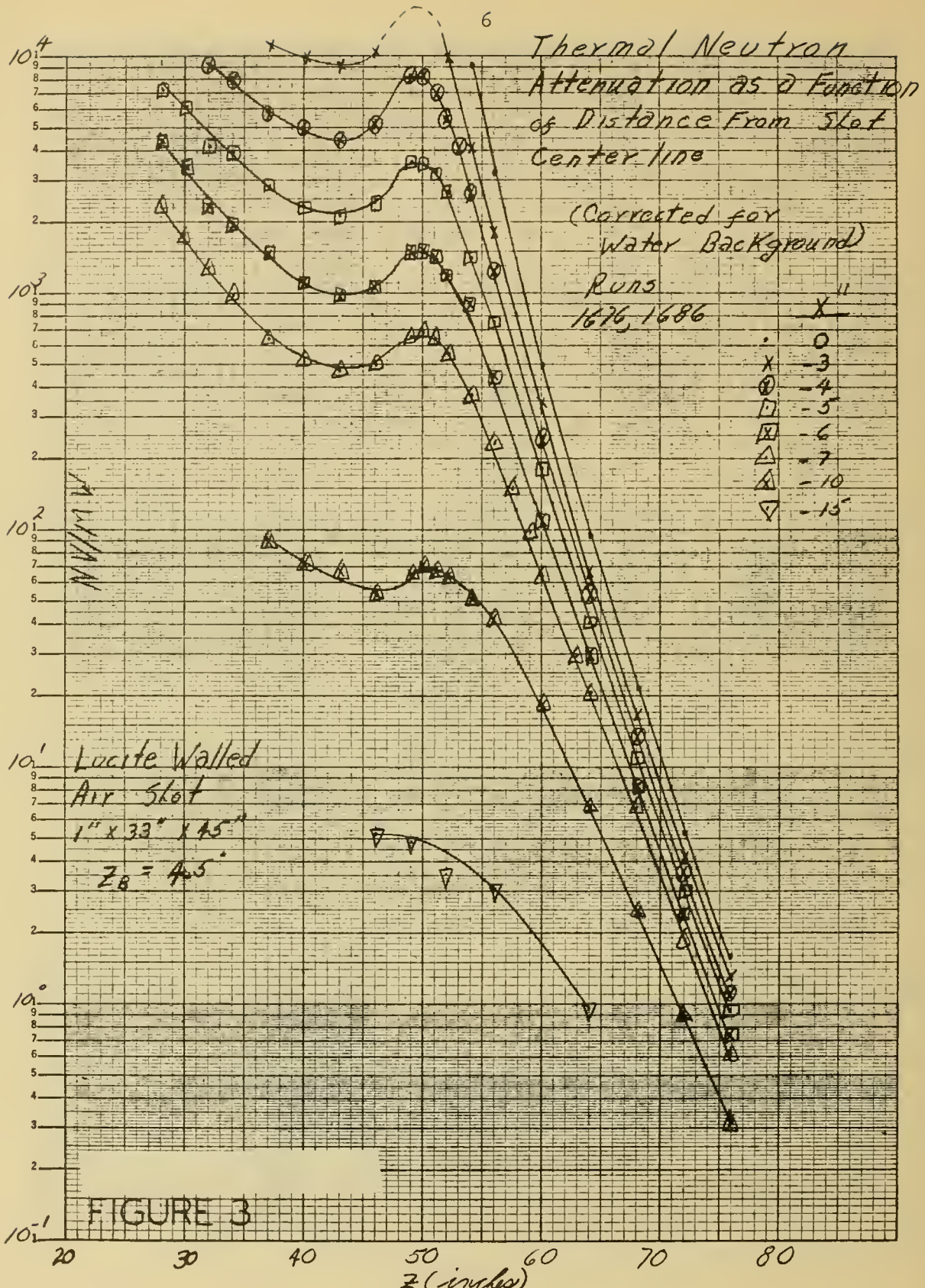
Thermal Neutron Attenuation as a Function of Distance From Slot Center line
(Corrected for Water Background)
Runs 1676, 1686
X"
0
-3
-4
-5
-6
-7
-10
-15
Lucite Walled Air Slot
1" x 33" x 45"
Z_B = 4.5"
NW/m²
Z (inches)
20
30
40
50
60
70
80

FIGURE 3

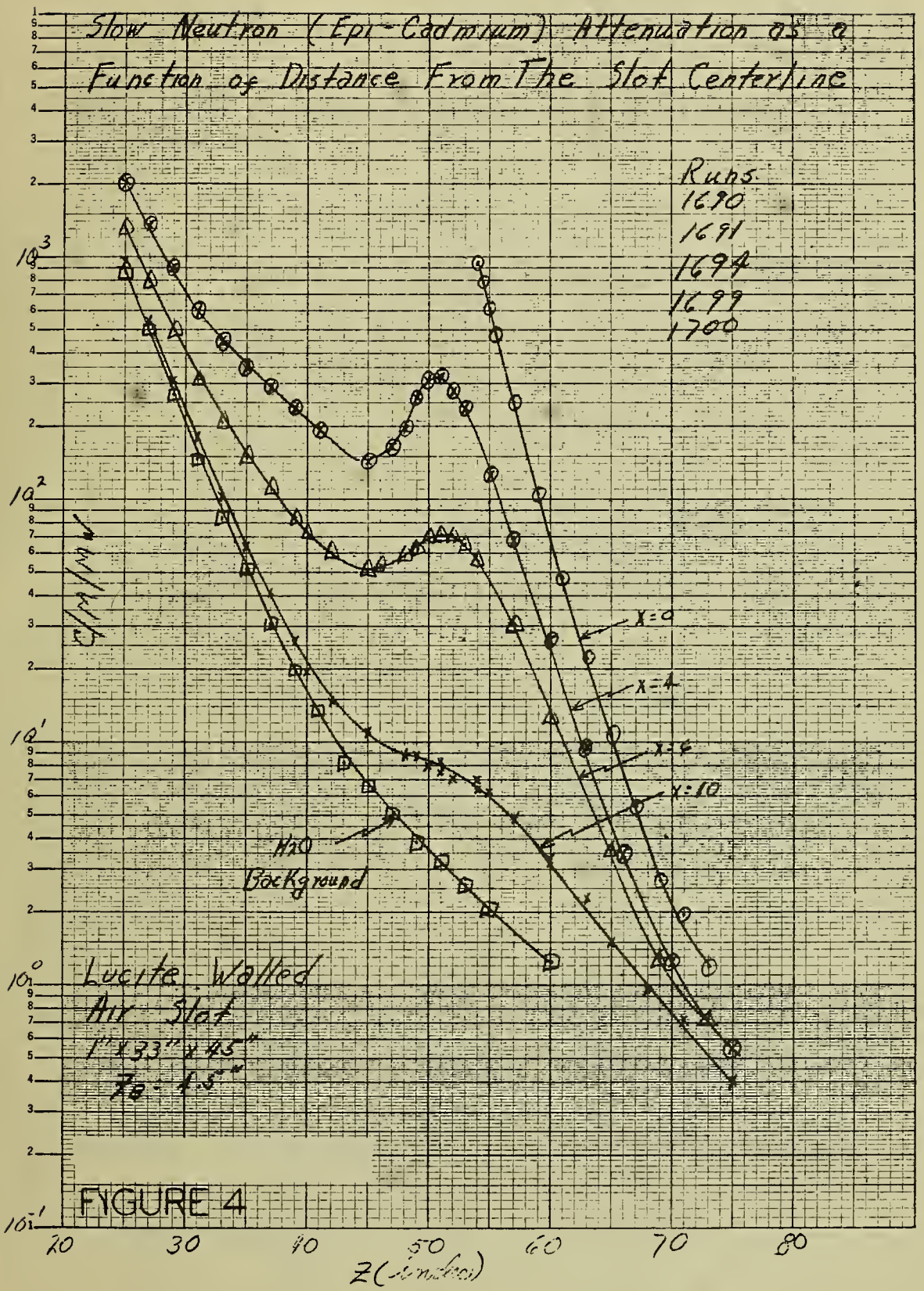
Slow Neutron (Epi-Cadmium) Attenuation as a Function of Distance From The Slot Centerline
Runs
1690
1691
1694
1699
1700
X=0
X=4
X=6
X=10
H2O
Background
Lucite Walled
Air Slot
1" x 33" x 45"
Z(inches)

FIGURE 4

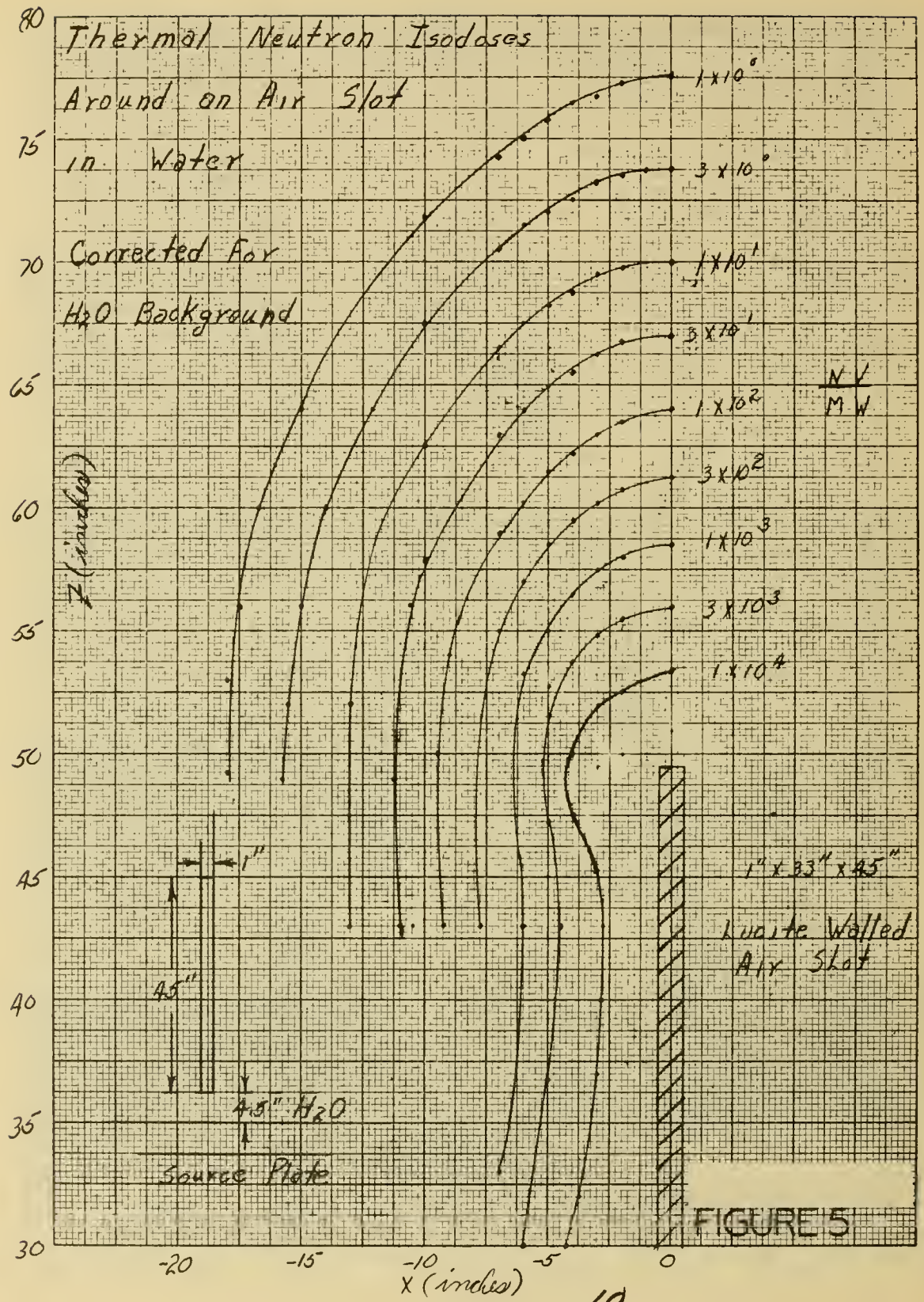
Thermal Neutron Isodoses
Around an Air Slot
in Water
Corrected For
H_2O Background
1×10^6
3×10^6
1×10^1
3×10^1
1×10^2
3×10^2
1×10^3
3×10^3
1×10^4
$\frac{N\,V}{M\,W}$
Z (inches)
80
75
70
65
60
55
50
45
40
35
30
1"
45"
4.5" H_2O
Source Plate
1" x 33" x 45"
Water Walled
Air Slot
-20
-15
-10
-5
0
X (inches)

FIGURE 5

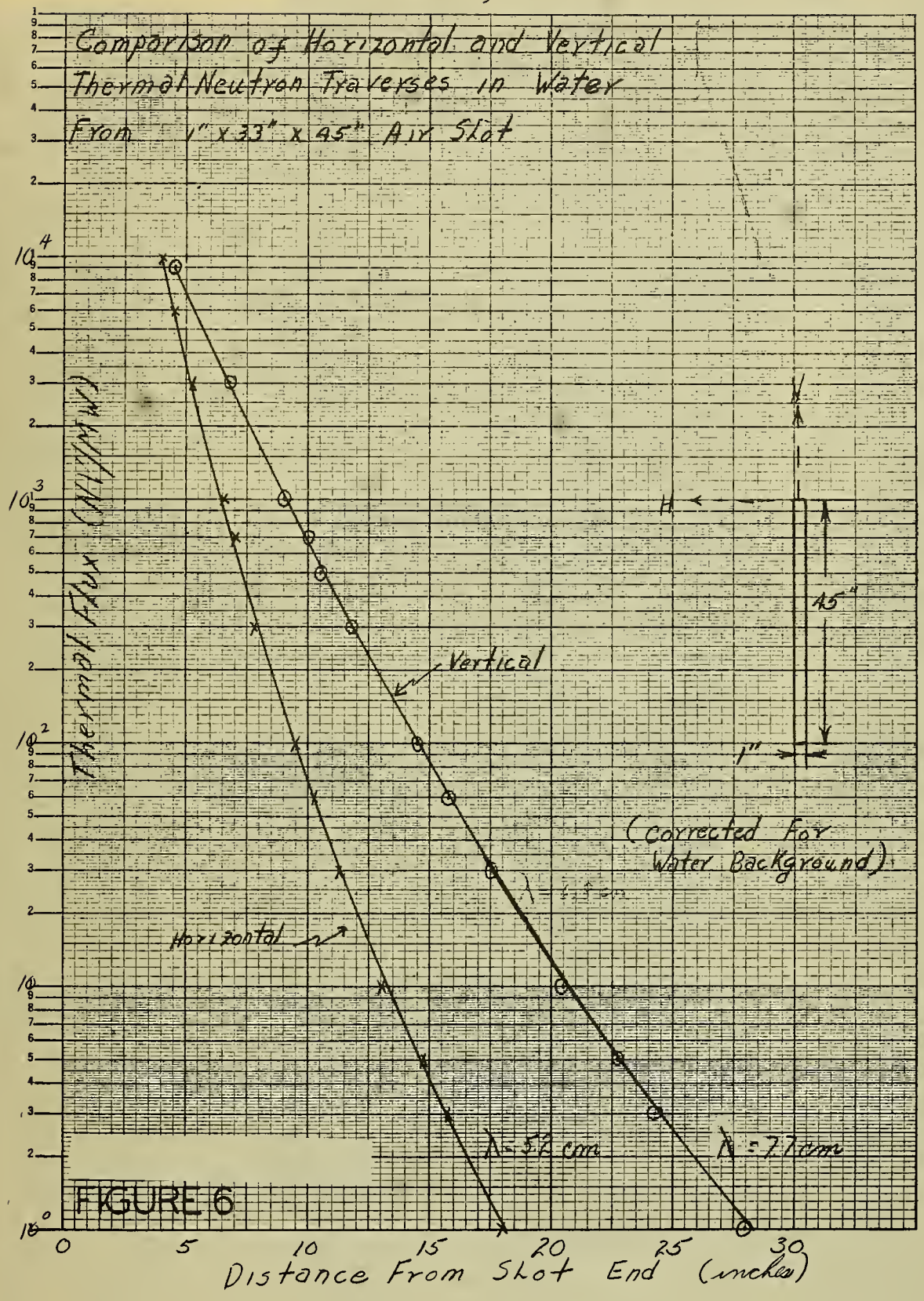
Comparison of Horizontal and Vertical
Thermal Neutron Traverses in Water
From 1" x 33" x 45" Air Slot
Thermal Neutron Intensity
Vertical
Horizontal
H
45"
1"
(Corrected for
Water Background)
λ = 5.8 cm
λ = 7.7 cm
Distance From Slot End (inches)

FIGURE 6

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3 1262 08230 040 0

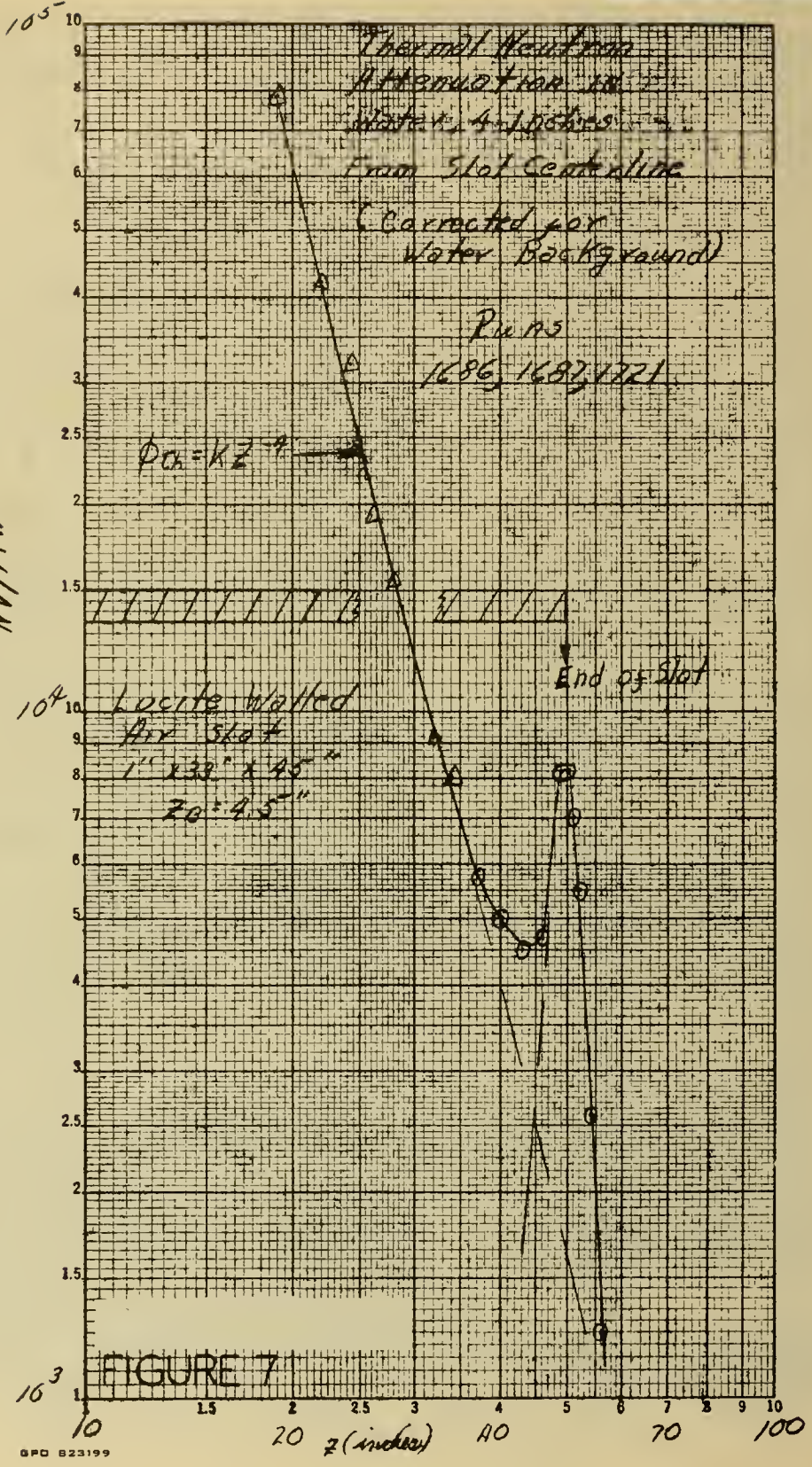

FIGURE 7

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